

### *Multimedia Datacasting for Broadcasters*



#### **Television**

broadcasters can add an all-new revenue stream to their existing operations. A Multimedia

#### **Datacasting**

partnership with

WavePhore allows broadcasters to sell a variety of services to their viewers virtually overnight.

WavePhore's Multimedia Datacasting system is compatible with all analog TV broadcast systems.

### *Multimedia Datacasting for Business*

Businesses need the ability to distribute common data to branch offices and clients.

Multimedia Datacasting now makes it possible to simplify distribution of information to the people who need it most — without wasted time, shipping costs and paper waste. With their WavePhore-equipped PCs, businesses can subscribe to services from content providers or create proprietary networks of their own.

Branch offices can receive vital, time-critical information at a fraction of the cost required for conventional methods. Information can be received, viewed and used on the company's existing computer network.

### *Multimedia Datacasting for Content Providers*

Multimedia Datacasting provides a low-cost distribution solution for



newspapers, magazines and other information service providers.

WavePhore provides the distribution technology content providers and broadcasters need to reach every home and business in North America and the world. Content providers will be able to market their products through agreements with WavePhore broadcasters who are equipped with WavePhore's Multimedia Datacasting systems.



### *Multimedia Datacasting for Homes*

Home uses for Multimedia Datacasting are nearly without limit. Many

home-based businesses and

telecommuters are PC-

equipped. Multimedia

Datacasting provides a chan-

nel for content providers

and broadcasters to tap

into a new marketplace hungry for electronic information.

Multimedia Datacasting offers home users the ability to receive entire newspapers, magazines, computer games, music, sports information, entertainment and other services.

# WavePhore's Multimedia Datacasting™ Service.

## The low-cost delivery solution for PC-ready information

*WavePhore delivers news, software, business information and entertainment to millions of subscriber PCs*

WavePhore is delivering PC-ready information anywhere within TV's reach using Multimedia Datacasting.

Multimedia Datacasting uses the existing TV broadcast infrastructure and adds a new high-speed, low-cost data distribution channel to reach PC users. It is a proven technology, simple to use, and always available – just like your TV.



Multimedia Datacasting is the next giant leap for delivery of information from one point to many. It gives people the ability to receive – and harness – information more effectively.

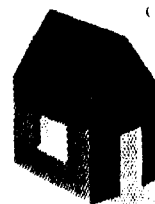
We've made it possible for millions of PC-equipped homes and businesses to receive digital information simultaneously – faster and much less expensively than ever before.



Our mission is to bring Multimedia Datacasting services to PC users worldwide. To reach this goal, we are developing strategic relationships with broadcasters and content providers to position WavePhore as the premier Multimedia Datacasting provider.

*WavePhore – the leader in high speed, low cost data delivery*

WavePhore has pioneered the technology of Multimedia Datacasting and is committed to the development of systems that will bring high-speed, low-cost data delivery services throughout the world.



Our Multimedia Datacasting technology is positioned to become the de facto standard for transmission

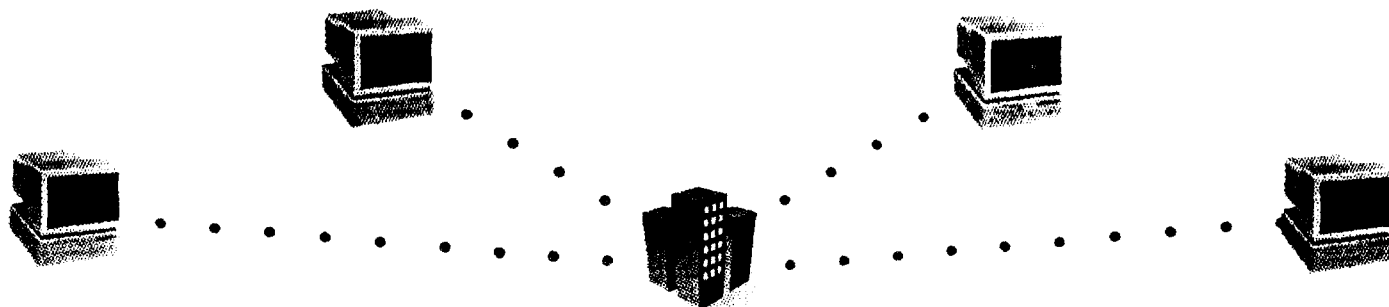
of digital data over existing analog TV signals.

WavePhore will continuously develop new datacasting technologies to satisfy the information needs created by the exploding information marketplace.

### How Datacasting Works

Content providers deliver digital information to a WavePhore server location. This information is then scheduled for delivery through local cable, satellite or TV broadcasters who use WavePhore's Multimedia

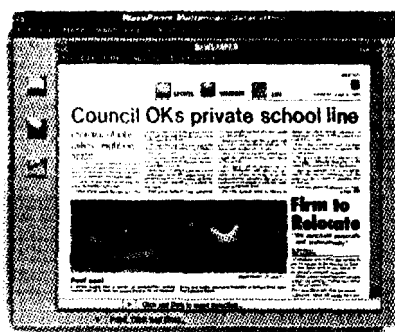
Datacasting system to insert and transmit digital information via ordinary TV signals. The information is received on PCs via WavePhore products where it can be stored and manipulated.



# Instant, low-cost, digital data delivery ready today

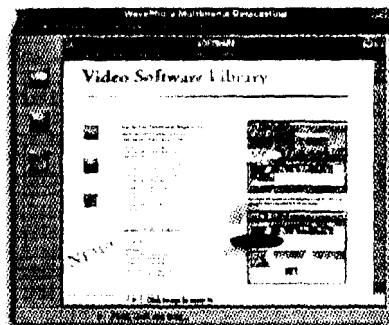
## *Newspapers delivered to PCs*

Instant delivery of newspapers and magazines offers publishers a low cost, high speed alternative to conventional distribution. Digital newspapers can become an entire new revenue stream — offering subscribers a wide range of “personalized” newspapers and publications.



## *Software delivery to millions of users*

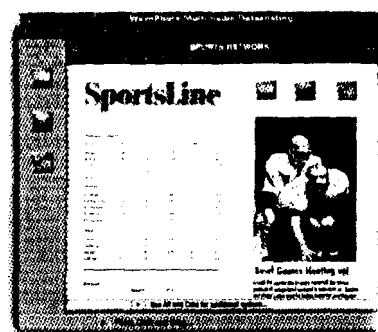
Multimedia Datacasting will reduce the costs of software distribution, eliminating mailing and shipping costs, expediting the delivery of software products to homes and businesses.



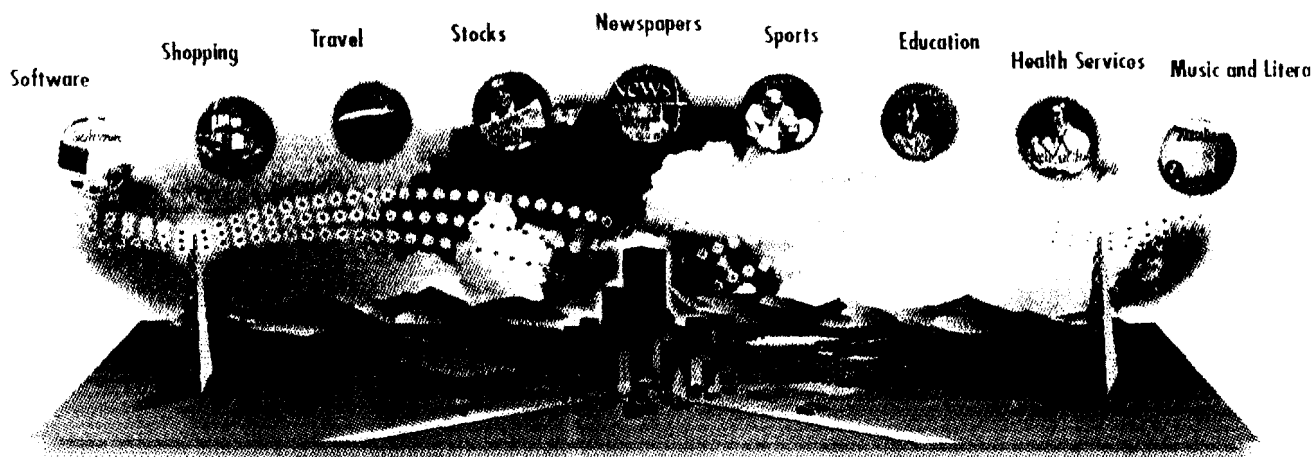
Software publishers can update millions of users at the same time by transmitting entire programs in seconds to users who may choose to sample or purchase their products.

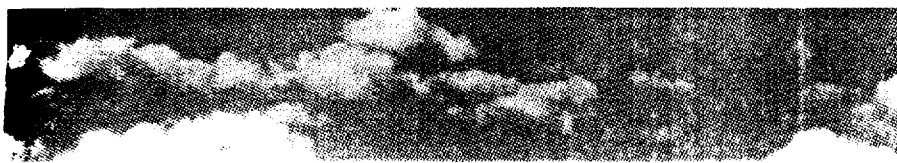
## *Sports information at your fingertips*

Existing sports news services provide scores and not much else. Multimedia Datacasting can provide color photos, audio clips, plays of the day and much more.



**Multimedia Datacasting - today's digital data revenue stream.**





### *Travel industry schedules, rates*

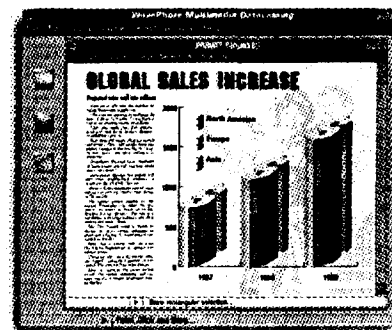
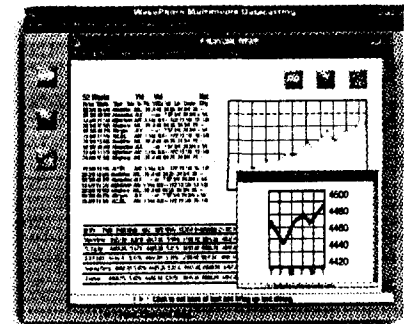
Travel agencies receive airline, train and seat availability schedule changes, hotel, rental car, etc.

### *Financial news and stock quotes*

Multimedia Datacasting allows users to receive up-to-date stock and financial information and news on their home PCs for a fraction of the cost of conventional methods.

### *Private business datacasting networks*

Businesses throughout the world can distribute internal memorandums, sales reports, inventory and other corporate-wide communications to all locations simultaneously.



WavePhone



MULTIMEDIA DATACASTING

*Multimedia Datacasting  
is here – ready today.*

Whether you're a broadcaster, content provider, business or home user, Multimedia Datacasting promises to revolutionize your life without a huge capital investment. In fact, because Multimedia Datacasting is available through your television signal today, the industry can add this new service for just pennies per subscriber.

WavePhore, Inc., a publicly traded company (NASDAQ: "WAVO") based in Tempe, Arizona, has developed proprietary products and services for the low-cost, high-speed distribution of digital data via the existing worldwide broadcast television infrastructure. The company operates a wholly-owned subsidiary, WavePhore Canada, in Montreal, Quebec.

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for more information:*

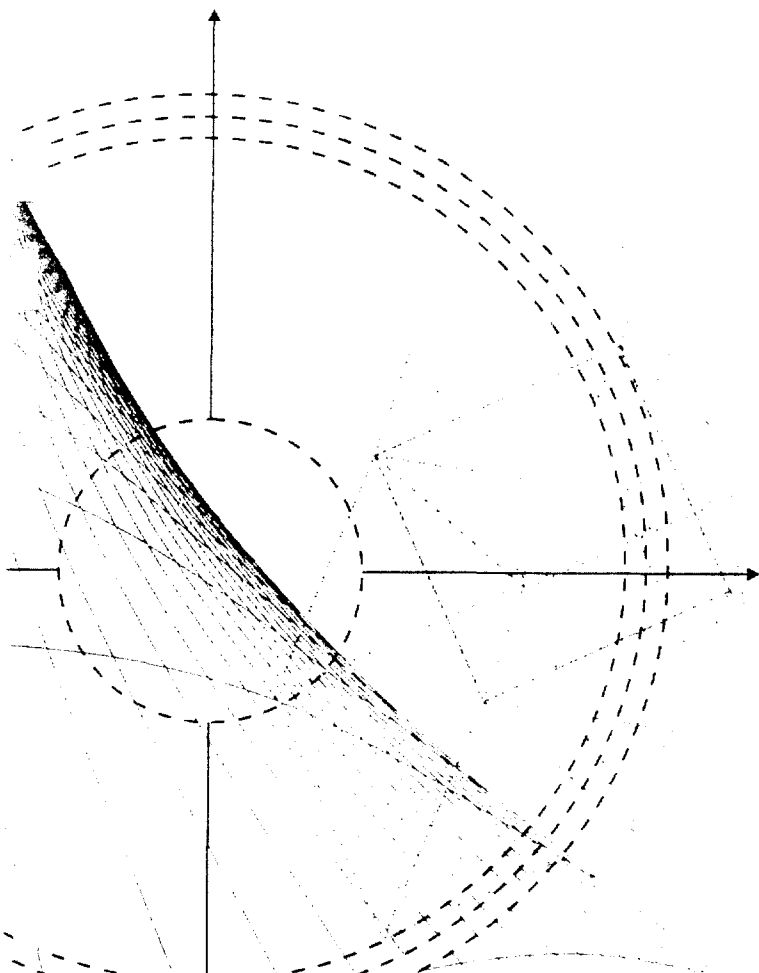
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# **Assessment of the Picture Quality of NTSC Television Carrying Data with the WavePhone TVT1/4 System**

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# **Assessment of Picture Quality of NTSC Television Carrying Data with the WavePhore TVT1/4 System**

By

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Work performed for  
WavePhore, Inc.

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## EXECUTIVE SUMMARY

The purpose of the tests carried out at CRC's Advanced Television Evaluation Laboratory (ATEL) was to subjectively assess using non-expert viewers the effects on the quality of the received video image sequences through the introduction of high speed data by the WavePhore TVT1/4 data system into the NTSC television system.

The tests were carried out using six video sequences, which were selected jointly by WavePhore, Inc. and CRC to represent typical television programming material. Two of those sequences were taken from film, and four from original video recordings. The original test material was at studio quality conforming to the ITU-R Recommendation 609 format. For test purposes the sequences were passed through an NTSC modulator and received by a typical consumer TV receiver and recorded. These recordings were used as Reference. In order to assess the effects of the data system on the received video quality, the same sequences were also passed through the WavePhore TVT1/4 encoder before they were NTSC modulated and fed to the TV receiver for recording. The video output from the receiver was recorded for both the "DATA ON" and "DATA OFF" conditions. These two recordings were designated Test. The tapes containing the Reference and the two Test cases in a pseudo-random order were then viewed by 26 non-expert viewers for video quality assessment purposes in a viewing environment that was complying with the ITU-R Recommendation 500 for critical video quality assessment.

The video quality assessment analyses indicate, that under the test conditions and for the video test sequences used, the introduction of the WavePhore TVT1/4 high speed data system into the NTSC television system (DATA ON or DATA OFF), did not result in any degradation of perceived video quality. No statistically significant differences were found between Reference and Test sequences.



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## **1.0    OBJECTIVES**

The purpose of the tests carried out at CRC's Advanced Television Evaluation Laboratory (ATEL) was to subjectively assess using non-expert viewers the effects of the introduction of high speed data by the WavePhore TVT1/4 data system into the NTSC television system on the quality of the received video image sequences. The WavePhore TVT1/4 data system uses a data subcarrier located at 4.197 MHz above the picture carrier. After filtering the modulated signal, in particular removing most of the upper side band, the data signal occupies a bandwidth of approximately 300 kHz, primarily below the 4.197 MHz carrier. The net data throughput, excluding error correction ranges between 384 kb/s to 393 kb/s.



## **2.0 PREPARATION OF TEST MATERIAL**

### **2.1 Test Material**

It was mutually agreed to between CRC/ATEL and WavePhore, Inc. to use six different sequences that would be representative of typical television programming. Two of the test material sequences originated from film and the remaining four sequences were video material which ranged from less sensitive material to critically sensitive material. The following briefly describes the test material:

- Dances with Wolves (P1):* This sequence, originating as film, contains 5 brief scenes, many with fast motion. The images are soft, hazy, and somewhat noisy.
- Red Rock (P2):* This sequence, originating as film, shows a car slowly moving on a dirt road in a country town. The images are crisp with slow camera movements throughout.
- TSN Baseball (P3):* This sequence, originating as video, contains complex movement, a detailed background, text overlays, and a scene cut to a harbourfront.
- Bus/Truck (P4):* This sequence, originating as video, concatenates two highly detailed street scenes containing complex movements.
- Flower Garden (P5):* This sequence, originating as video, contains a high level of luminance and chrominance detail. This segment is drawn from a longer ITU-R<sup>1</sup> test sequence.
- Mobile & Calendar (P6):* This sequence, originating as video, is highly detailed, and contains complex motion and highly saturated colours. This segment is drawn from a ITU-R test sequence.

The test material originated from broadcast studio quality conforming to the ITU-R Recommendation 609 in the 4:2:2 format.

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<sup>1</sup> ITU-R., International Telecommunications Union Radiocommunication Sector, an organization of the International Telecommunications Union, a United Nations agency. Formerly called the CCIR. (International Radio Consultative Committee)

## **2.2    Test Set-Up**

The test set-up to record the video output from a typical consumer television receiver is shown in Appendix B, FIGURE 1.

## **2.3    Recording of Reference Sequences**

The high quality source material was played back from a Sony model DVR-10 digital video recorder in D2 format. In order to simulate the receive conditions of a basic NTSC television signal, that is, without the insertion of the WavePhore data transmission subsystem, the output of the video recorder was fed into the NTSC modulator. The modulator was adjusted so that the audio carrier power was equal to 5% of the video carrier power. The output of the NTSC modulator set to a moderate (-35 dBm peak-of-sync) RF level by means of a step attenuator, was fed into the Sony model KV25XBR receiver. The demodulated baseband video signal with a bandwidth of 3.9 Mhz (-3dB), was then recorded on a Sony, model PW2800 Betacam SP recorder.

Since the Mitsubishi, model CS-3520 R monitor was to be used for the viewing of the test sequences by the non-expert viewers for assessment purposes , it was verified, that no further visible artifacts with respect to the images on the Sony, model KV25XBR receiver were created.

## **2.4    Recording of the Test Sequence.**

Two further recordings were also made to represent decoded NTSC video signals where the WavePhore data system was inserted in the NTSC baseband signal with and without data being carried. For this purpose the source video signal from the Sony, model DVR-10 recorder was inserted into WavePhore's encoder and the combined output was then fed into the modulator input. WavePhore's encoder was set to a data injection level of 42 mV. For the case where data transmission was to be simulated, the output of a pseudo-random data generator was inserted into the WavePhore encoder.

The tape containing the recorded reference and test sequences, is referred to as the Parent Master tape.

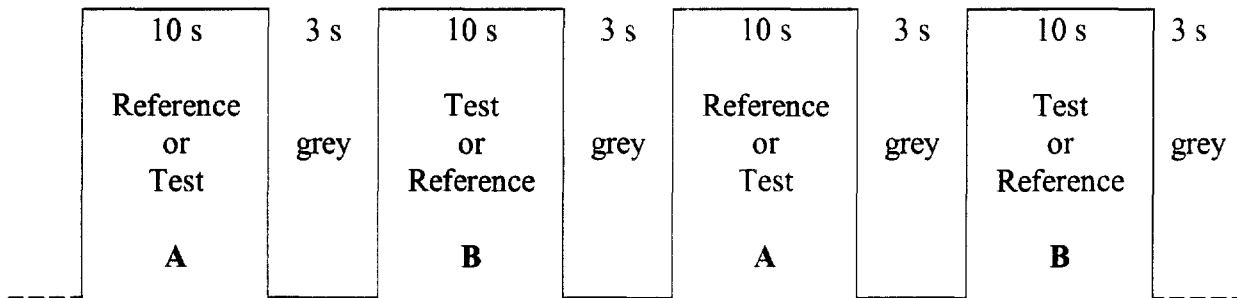
### 3.0 SUBJECTIVE ASSESSMENT

#### 3.1 Methodology

In this assessment the effect of the insertion of data by the WavePhore TVT1/4 system on the basic quality of the received NTSC video picture was assessed. No tests were carried out on possible degradations that might be caused due to transmission channel impairments.

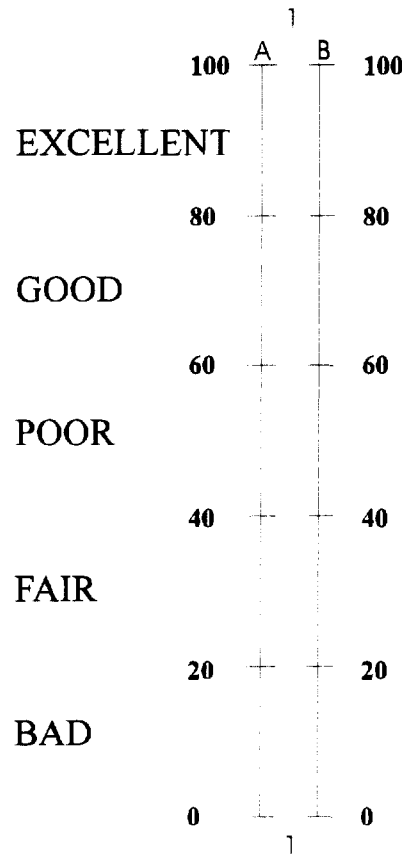
For the subjective assessment the double-stimulus continuous quality scale method described in ITU-R Recommendation 500 was used.

With this method 'trials' are used to present the material. Each trial consists of four 10 second presentations as shown in FIGURE 1.



**FIGURE 1. Layout of an assessment trial using the double-stimulus continuous quality-scale method.**

The two 'A' presentations are identical and similarly the two 'B' presentations are identical. During the first A and B presentations, viewers only observe these sequences. During the second A and B presentations viewers observe, judge and record separately the quality of the A and B presentations on the scale shown in FIGURE 2.



**FIGURE 2. Judgment scales in assessments using the double-stimulus continuous quality-scale method.**

These judgement scales are 100 units in length. Measurement values between 0 and 20 correspond to judgements of "BAD", values between 20 and 40 correspond to "POOR", values between 40 and 60 to "FAIR", values between 60 and 80 to "GOOD", and values between 80 and 100 to "EXCELLENT".

Viewers are unaware which of the A or B presentations is the Test or the Reference sequence. For each of the conditions of "DATA ON" and "DATA OFF" the six test pictures appear once on the tape with the A-B pair being ordered as Test-Reference, and once in a different trial being ordered as Reference-Test. The resulting 24 trials occur on the tape in pseudo-random order. Approximately half the viewers are shown one random order and the balance a completely different random order.

### **3.2 PREPARATION OF RANDOMIZED TEST TAPES**

Material recorded on the Parent Master tape was edited to produce a test tape containing two distinct pseudo-random orders. Each random order contained 24 trials, based on 6 sequences each with two trial conditions (R-T and T-R) and two test cases (DATA ON and DATA OFF). An additional 5 warm-up trials were also required, to be placed at the head of each randomization.

Two randomizations were produced that met the following conditions:

- a) there were to be a minimum of 3 trials between any 2 repeated pictures,
- b) a maximum of 4 consecutive identical trial conditions were to be permitted,
- c) no more than 4 consecutive identical test cases were to be permitted.

The warm-up trials were not randomized. Rather, they were to represent, as broadly as possible, the trial conditions and test cases presented by the actual test material. The warm-up trials were identical for both randomizations. Note that data collected from these warm-up trials was not used.

The Parent Master recording, in Betacam SP format, was utilized as source and edited onto a DVR-10 D2 format VTR, the same machine used for viewer session playbacks. The composite video output of the Betacam SP recorder was connected directly to the analogue input of the D2 recorder. Editing control was achieved via the RS-422A remote interface, available on both VTRs. Grey periods between trials were sourced directly from the Leader 408 NTSC Pattern Generator. Audio announcements (trial numbering) were sourced from a Panasonic SV-3700 digital audio tape deck.

The resulting tape contained 2 distinct orders, each having 5 warm-up and 24 test trials, for a running time of 25:05 per randomization.

### **3.3 Viewing Conditions**

The viewing environment is designed such, that nothing but the displayed video sequences capture the attention of the viewer. The ATEL viewing room specification which is based on ITU-R Recommendation 500, is shown in TABLE 4 of APPENDIX C.



### **3.4     Playback and Distribution**

The randomized test sequences tape, which was recorded in the D2 format was played back on a Sony DVR-10 professional tape recorder. The output signal in composite form was delivered from the equipment room of the ATEL facility to a Mitsubishi, model CS-3520R direct view monitor in the viewing room via a high quality distribution system ensuring that no degradation was introduced into the signals being played back.

### **3.5     Assessment Viewers**

In recruiting viewers, the intent was to select from members of the general viewing public. Accordingly, potential viewers were screened for visual acuity (normal or corrected-to-normal), contrast sensitivity (normal) and color vision (normal). Those who met the screening criteria were permitted to take part in the tests.

### **3.6     Viewing Sessions**

Three viewing sessions were conducted on 4 April 1995 for random order 1. There were 12 participants, 8 females and 4 males.

Three viewing sessions were conducted on 5 April 1995 for random order 2. There were 14 participants, 8 females and 6 males.

## **4.0    ASSESSMENT RESULTS**

### **4.1    Quality Verification**

It was verified that the technical quality of the test tapes and the performance of the laboratory met all the requirements and revealed no significant variances that could affect the interpretation of the assessment data. Further details on the Test Material; Playback, Test Configuration and Distribution; and Viewing Conditions are to be found in APPENDICES A, B and C respectively.

Extensive analyses were conducted to verify that the collected data conformed to the underlying assumptions for the statistical analysis method used.

Finally it was verified that the viewers performed within accepted limits of consistency. It was also confirmed that judgments of the video quality were not unduly influenced by factors other than the effects caused by the introduction of the WavePhore TVT1/4 data system into the NTSC television signal. Further details are available in APPENDICES D and E.

### **4.2    Data Analysis Results**

The basic analyses examined the mean quality judgements given to the Reference and the two Test cases. Quality judgement, ranging between 0 and 100 were captured from the continuous quality scales used by assessment viewers.

TABLE 1 shows the mean quality judgments assigned to the Reference and the two Test cases.

TABLE 1

## Basic Received Quality

PICTURE NAME	TEST ITEM	SCORE (OF 100)/STANDARD DEVIATION					STATISTICAL OUTCOME
		REFERENCE		TEST			
		Mean	ST. Dev.	Mean	ST.Dev.	Data	
Dances with Wolves	P1 / Film	71.47	12.58	73.57	11.87	ON	NOT SIGNIFICANT
Red Rock	P2 / Film	66.34	17.20	65.90	17.37	ON	NOT SIGNIFICANT
TSN Baseball	P3 / Video	67.08	16.78	68.42	14.89	ON	NOT SIGNIFICANT
Bus\Truck	P4 / Video	74.08	12.34	74.31	12.64	ON	NOT SIGNIFICANT
Flower Garden	P5 / Video	71.89	13.62	71.12	14.77	ON	NOT SIGNIFICANT
Mobile & Calendar	P6 / Video	67.62	20.09	67.34	19.96	ON	NOT SIGNIFICANT
Dances with Wolves	P1 / Film	74.67	11.24	75.11	10.86	OFF	NOT SIGNIFICANT
Red Rock	P2 / Film	66.78	17.02	67.45	16.60	OFF	NOT SIGNIFICANT
TSN Baseball	P3 / Video	70.36	13.53	69.53	14.61	OFF	NOT SIGNIFICANT
Bus\Truck	P4 / Video	75.13	14.18	74.06	13.14	OFF	NOT SIGNIFICANT
Flower Garden	P5 / Video	71.55	14.08	71.43	14.86	OFF	NOT SIGNIFICANT
Mobile & Calendar	P6 / Video	66.89	19.30	66.29	19.33	OFF	NOT SIGNIFICANT

COMMENTS:

1.

52 observations per entry (26 viewers x 2 trials); with the exception of 'Dances with Wolves' (P1) Data ON, 50 observations (25 viewers x 2 trials) missing data point.

2.

All TEST vs.REFERENCE statistical outcomes evaluated by a F-test (2-tailed).

3.

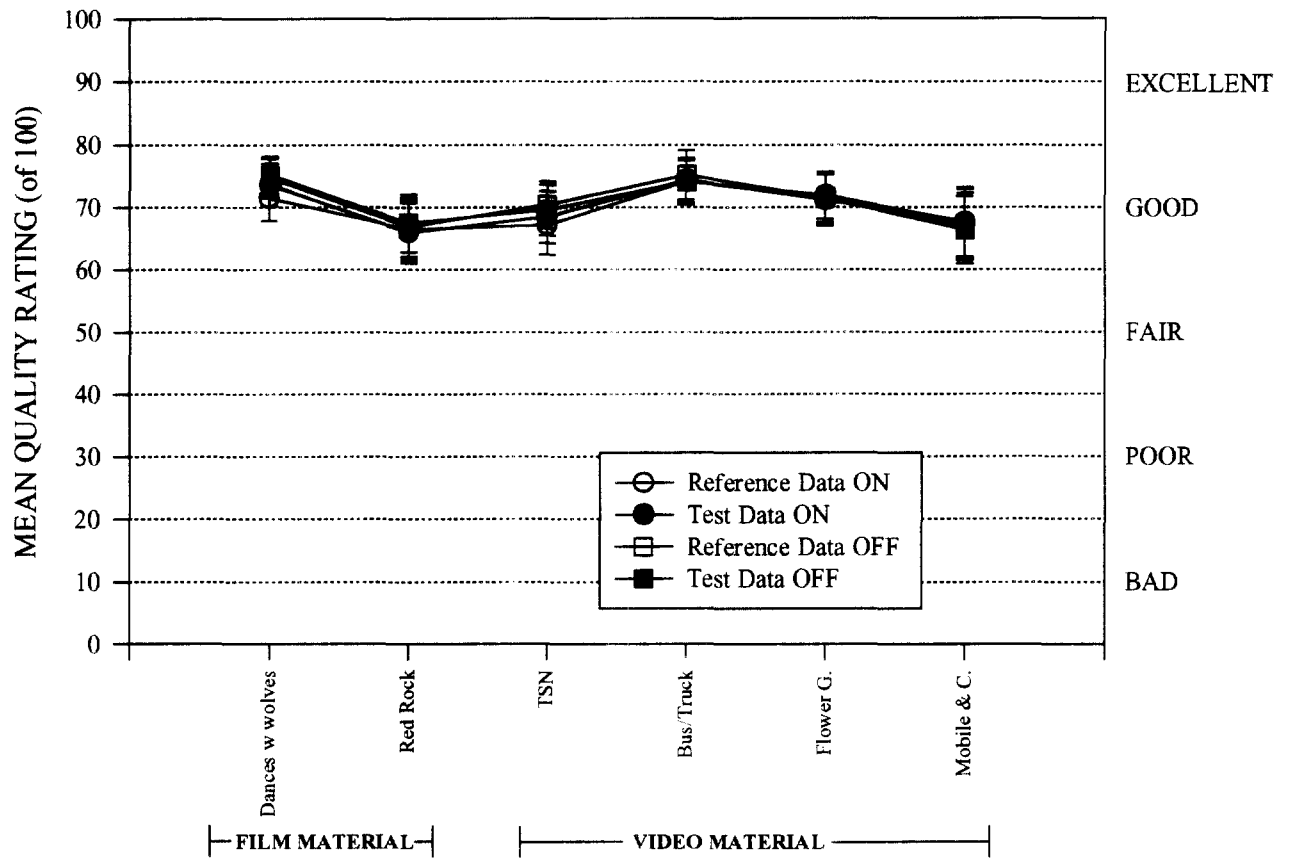
Average Confidence Limits (in points of 100):

REFERENCE		TEST	
Data ON (Overall)	±4.32	Data ON (Overall)	±4.26
Data ON (Film)	±4.19	Data ON (Film)	±4.12
Data ON (Video)	±4.38	Data ON (Video)	±4.34
Data OFF (Overall)	±4.15	Data OFF (Overall)	±4.15
Data OFF (Film)	±3.94	Data OFF (Film)	±3.83
Data OFF (Video)	±4.25	Data OFF (Video)	±4.31

4.

For convenient inspection, a graph is provided in FIGURE 3.

These Results are also shown graphically in FIGURE 3. On the graphs, 95% confidence intervals are indicated around the means for each picture.



**FIGURE 3. Mean Quality Judgements Assigned To REFERENCE and TEST**

It should be noted that differences between the Reference and the Test means be regarded as a better measure of performance, because the absolute placement of these individual values on the judgement scale of 100, varies relative to the experience of each viewer. TABLE 2 shows the difference values in judged quality between the Reference and Test cases.

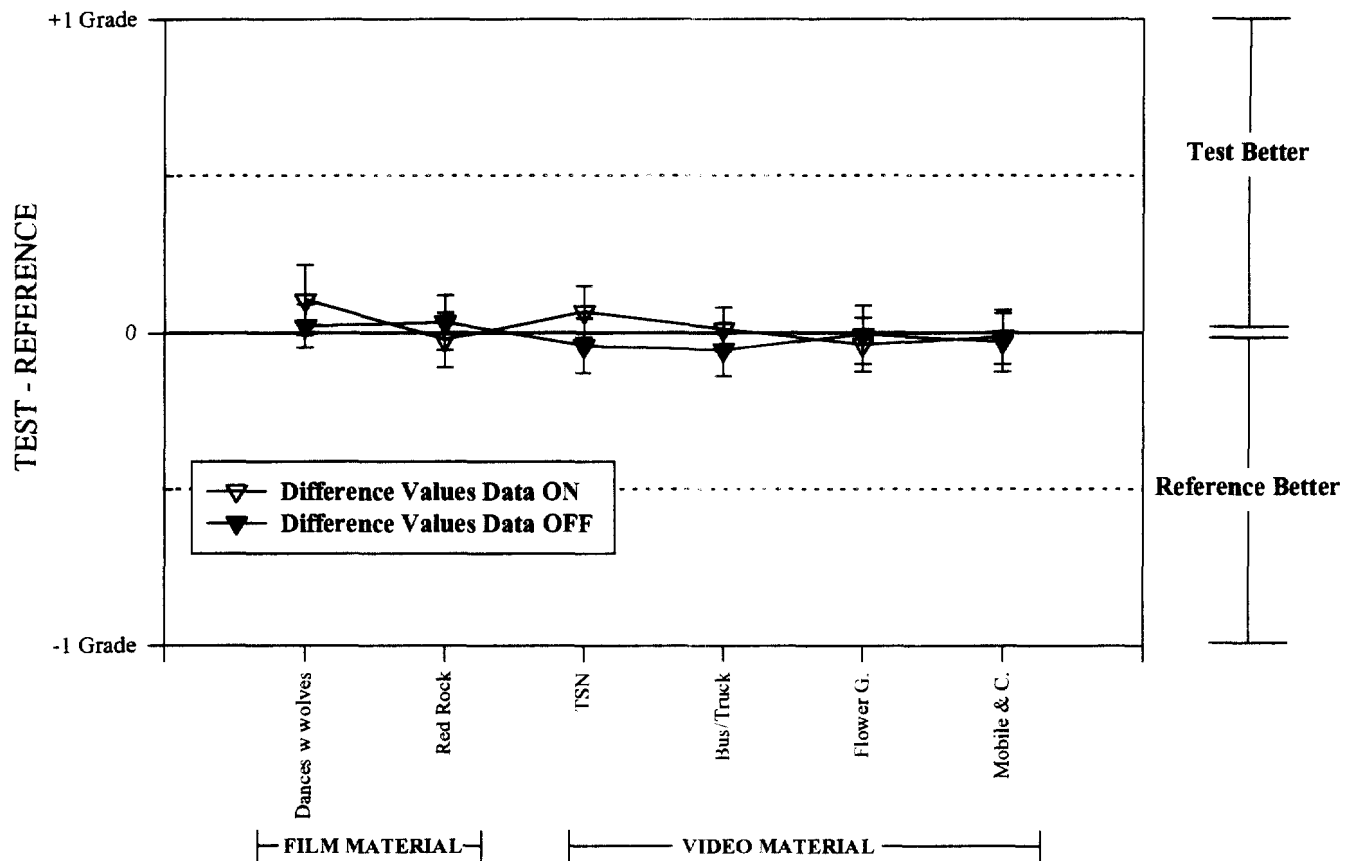
**TABLE 2**

**Differences In Quality Judgements Between TEST and REFERENCE**

PICTURE NAME	TEST ITEM	DATA	MEAN DIFFERENCE/STANDARD DEVIATION		STATISTICAL OUTCOME
			TEST - REFERENCE		
			Mean	ST.Dev.	
Dances with Wolves	P1 / Film	ON	2.09	7.80	NOT SIGNIFICANT
Red Rock	P2 / Film	ON	-0.44	6.28	NOT SIGNIFICANT
TSN Baseball	P3 / Video	ON	1.34	5.87	NOT SIGNIFICANT
Bus\Truck	P4 / Video	ON	0.23	5.02	NOT SIGNIFICANT
Flower Garden	P5 / Video	ON	-0.77	6.16	NOT SIGNIFICANT
Mobile & Calendar	P6 / Video	ON	-0.27	6.19	NOT SIGNIFICANT
Dances with Wolves	P1 / Film	OFF	0.43	4.92	NOT SIGNIFICANT
Red Rock	P2 / Film	OFF	0.67	6.24	NOT SIGNIFICANT
TSN Baseball	P3 / Video	OFF	-0.83	6.33	NOT SIGNIFICANT
Bus\Truck	P4 / Video	OFF	-1.07	6.07	NOT SIGNIFICANT
Flower Garden	P5 / Video	OFF	-0.11	6.76	NOT SIGNIFICANT
Mobile & Calendar	P6 / Video	OFF	-0.59	6.72	NOT SIGNIFICANT
COMMENTS:					
1. 52 observations per entry (26 viewers x 2 trials); with the exception of 'Dances with Wolves' (P1) Data ON, 50 observations (25 viewers x 2 trials) missing data point.					
2. All TEST vs.REFERENCE statistical outcomes evaluated by a F-test (2 tailed)					
3. Average Confidence Limits (in points of 100):					
			Data ON (Overall)	±1.74	
			Data ON (Film)	±1.99	
			Data ON (Video)	±1.62	
			Data OFF (Overall)	±1.72	
			Data OFF (Film)	±1.56	
			Data OFF (Video)	±1.80	
4. For convenient inspection, a graph is provided in FIGURE 4.					

In the table 95% confidence limit are calculated separately for the "DATA ON" and "DATA OFF" in the categories of overall, film and video material. In the graphs 95% confidence intervals are indicated for each Reference-Test.

It should be noted that a difference smaller than the individual confidence limit for each picture (see Appendix E, Picture Confidence Intervals) usually indicates that the result is not statistically significant. The tables and the graphs indicate, the quality differences for both "DATA ON" and "DATA OFF" for all sequences are statistically not significant.



**FIGURE 4. Differences In Quality Judgements Between TEST and REFERENCE**

#### **4.3 Conclusions from Assessment**

The video quality assessment analyses indicate, that under the test conditions and for the video test sequences used, the introduction of the WavePhore TVT1/4 high speed data system into the NTSC television system, did not result in any statistically significant differences in the subjectively perceived video quality. With or without the data actually being transmitted, as compared to the quality of the Reference NTSC received video sequences. This is true for both cases of "DATA ON" and "DATA OFF."



## **APPENDICES**

- A - Review of Test Material**
- B - Playback, Test Configuration, and Distribution**
- C - Viewing Conditions**
- D - Glossary of Statistical Terms**
- E - Data and Analysis**



